Ammonia Generating Apparatus

BACKGROUND OF THE INVENTION

The present invention relates to an ammonia generating apparatus for generating, from urea water, ammonia to be used for NOx removal systems in boilers or the like.

In recent years, there has been a demand for further reduction in NOx also for boilers. As one of countermeasures therefor, a method has been taken that a boiler is equipped with a NOx removal system, where ammonia as a reducing agent is added to combustion exhaust gas so that the NOx is reduced. Whereas this ammonia is generated by, for example, heating urea water, there is a desire for ammonia generating apparatuses having higher efficiency of heat transfer and a compact body.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide an ammonia generating apparatus having a high efficiency of heat transfer and being compact.

In order to achieve the above object, in a first aspect of the present invention, there is provided an ammonia generating apparatus comprising: a urea water introducing part; a flow passage for urea water to flow therethrough; and heating means, wherein the flow passage is connected to the urea water

introducing part, and the heating means heats urea water present within the flow passage.

In a second aspect of the present invention, there is provided an ammonia generating apparatus as described in the first aspect, wherein part of the flow passage is formed into a helical part, and the heating means is placed inside the helical part.

Now an embodiment of the present invention is described below. An ammonia generating apparatus according to the present invention has a urea water introducing part, a flow passage, and heating means. The urea water introducing part has an inlet nozzle for introducing urea water. The flow passage is connected to the urea water introducing part, and urea water flows through within the flow passage. The heating means, for heating the urea water within the flow passage to generate ammonia, is located in proximity to the flow passage. This heating means is implemented by, for example, an electric heater.

Part of the flow passage is laid out in a helical shape, and the heating means is placed inside this helical part. By this arrangement and placement, heat emitted from the heating means can be received by the whole helical part and, as a result, the amount of heat release to outside is suppressed as much as possible, thus allowing the efficiency of heat transfer to be improved. Then, by making effective use of a space formed inside

the helical part, the apparatus can be made more compact in construction as a whole and thus a space-saving apparatus.

In the flow passage, heat transfer inhibiting means is provided upstream of the helical part. This heat transfer inhibiting means functions to inhibit heat from being transferred from its mounting position to the upstream side, thereby preventing urea water from being crystallized by evaporation of moisture content before its arrival at the helical part, or preventing occurrences of unnecessary intermediates from the urea water, to a minimum. That is, according to studies by the inventors of the present application, it has been found out that it is within a temperature range of about 80 - 180° C that crystallization of urea water or generation of unnecessary intermediates is likely to take place. Thus, the heat transfer inhibiting means is so designed as to have an entrance temperature of not more than 80° C and an exit temperature of not less than 180° C, while the above temperature range occurs limitedly only to the site where the heat transfer inhibiting means is provided. Moreover, the length of the this temperature range site is made as short as possible, by which the crystallization of urea water or the generation of unnecessary intermediates is suppressed to a minimum.

The heat transfer inhibiting means is implemented by providing a member made of, for example, a material having a large heat insulating effect (e.g. ceramics) at a place halfway on the

flow passage. The heat transfer inhibiting means may also be designed so that air is introduced from outside, where heat transferred from the helical part side is collected by the air, and the flow of the air that has collected heat is directed toward the helical part so that the heat is returned to the helical part.

The inlet nozzle is equipped with an elastic sealing member in such a way that injection holes of the inlet nozzle are covered with the elastic sealing member. More specifically, with urea water introduced, when the urea water is pressurized, the elastic sealing member is pushed by pressure, causing the injection holes to be opened, so that the urea water flows out. Then with the urea water released from pressurization, the elastic sealing member returns to the original position, causing the injection holes to be closed. Consequently, while the urea water is not being introduced, the injection holes are sealed by the elastic sealing member and therefore the urea water remaining in the inlet nozzle is never crystallized by the evaporation of moisture content, ensuring the prevention of blockage of the inlet nozzle. In addition, the elastic sealing member is made of, for example, synthetic rubber.

An air supply line is connected to the urea water introducing part. Air supplied along this air supply line functions to convey urea water in the flow passage, and to blow out urea water deposited on the inlet nozzle. Accordingly, supplying air through the air supply line prevents the urea water

from residing, as it is deposited, within the urea water introducing part and the flow passage.

Further, in this ammonia generating apparatus, a cleaning fluid supply line for cleaning the interior of the flow passage is provided. This cleaning fluid supply line is connected to the upstream side of the heat transfer inhibiting means so that even if part of the urea water is crystallized, the crystallized urea water can be cleaned. As the cleaning fluid, water, vapor or the like is used.

As shown above, according to this constitution, the ammonia generating apparatus allows continuous heating to be performed while urea water is kept flowing, so that the efficiency of heat transfer can be greatly improved. That is, since urea water flows at a specified flow rate in the flow passage, the resulting efficiency of heat transfer is greatly improved, as compared with the case in which heating is done with the urea water residing in the tank. Besides, as compared with the case of heating with the urea water residing in the tank, the rise time from when urea water begins to be supplied to when a steady-state generation of ammonia is reached can be shortened, and the heating capacity of the heating means can be reduced. Further, the ammonia generating apparatus can be reduced in size as a whole, and in particular, with the heating means placed inside the helical part, the ammonia generating apparatus can be made more compact in structure.

In addition, the heating means may be provided either outside the helical part or both inside and outside thereof. The heating means may also be provided so as to surround the entire circumferential periphery of the flow passage along the flow passage.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a longitudinal sectional explanatory view of a first embodiment of the invention;

Fig. 2 is an enlarged longitudinal sectional explanatory view showing details of the urea water nozzle in Fig. 1;

Fig. 3 is an enlarged longitudinal sectional explanatory view showing details of the heat transfer inhibiting means in Fig. 1;

Fig. 4 is a longitudinal sectional explanatory view of a second embodiment of the invention; and

Fig. 5 is an enlarged longitudinal sectional explanatory view showing another embodiment of the heat transfer inhibiting means as a substitute for that of Fig. 3.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinbelow, concrete embodiments of the present invention are described in detail based on the accompanying drawings. First, a first embodiment shown in Figs. 1 - 3 is described.

The ammonia generating apparatus according to the present invention is designed to generate ammonia by heating urea water and, as shown in Fig. 1, has a urea water introducing part 1, where a flow passage 2 for urea water to flow therethrough is connected to the bottom of this urea water introducing part 1. The urea water introducing part 1 has an inlet nozzle 3 provided so as to be directed downward, and an air supply line 4 is connected to a side face of the urea water introducing part 1. This air supply line 4 is connected so as to be opposed to the forefront of the inlet nozzle 3, and air supplied along the air supply line 4 functions to convey urea water in the flow passage 2 and to blow out urea water deposited at the forefront of the inlet nozzle 3. In addition, the air supply line 4 may also be connected to the top face of the urea water introducing part 1 in parallel to the inlet nozzle 3.

Part of the flow passage 2 is laid out into a helical shape, forming a helical part 5, which is fixed to a cylindrical member 6 in close contact with the outer circumferential surface of the cylindrical member 6. Inside the cylindrical member 6, an electric heater as heating means 7 is provided at a specified spacing to the inner circumferential surface of the cylindrical member 6. Also, a temperature sensor 8 is provided in the space between the cylindrical member 6 and the heating means 7, and by detecting surface temperature of the heating means 7 with this temperature sensor 8, electric energy to be supplied to the

heating means 7 is controlled by a controller 9 so that the surface temperature of the heating means 7 becomes about 500° C. Accordingly, the urea water is heated by the heating means 7 while flowing within the helical part 5, by which gaseous ammonia is generated continuously. Further, outside the helical part 5, a heat insulating material 10 is provided so as to cover the entire helical part 5.

The flow passage 2 is so formed that its upstream side of the helical part 5 is slightly slanted in order to prevent the residence of urea water, and heat transfer inhibiting means 11 is provided at a specified position on this upstream side. This heat transfer inhibiting means 11 functions to inhibit heat from being transferred from its location to the upstream side, thereby inhibiting urea water from being crystallized by evaporation of moisture content before its arrival at the helical part 5, or inhibiting occurrences of unnecessary intermediates from the urea water, to a minimum.

The urea water introducing part 1 is so formed as to be larger in diameter than the flow passage 2, their junction portion being tapered downwardly so that the urea water does not accumulate.

Further, the flow passage 2 is connected at its downstream side end portion to a NOx removal system (not shown) provided in the boiler or the like, so that ammonia generated

in the helical part 5 is supplied continuously to the NOx removal system.

Next, construction of the inlet nozzle 3 is described in detail with reference to Fig. 2. As shown in Fig. 2, a plurality of injection holes 12, 12, ... are provided on the side wall of the inlet nozzle 3 on its front end side. Besides, a tubular elastic sealing member 13 is attached so as to cover these injection holes 12. More specifically, the elastic sealing member 13 is made of, for example, synthetic rubber, and when urea water is pressurized upon its introduction, the elastic sealing member 13 is pushed by the pressure, causing the injection holes 12 to be opened, so that the urea water flows out through between the outer circumferential surface of the inlet nozzle 3 and the inner circumferential surface of the elastic sealing member 13. When the urea water is released from pressurization, the elastic sealing member 13 returns to the original position, causing the injection holes 12 to be closed. In this connection, Fig. 2 shows a state in which the urea water is flowing out.

Therefore, with the elastic sealing member 13 provided, while the urea water is not being introduced, the injection holes 12 are sealed and closed by the elastic sealing member 13, thus preventing the occurrence that urea water remaining in the inlet nozzle 3 is crystallized by the evaporation of moisture content, and so ensuring the prevention of blockage of the inlet nozzle 3.

Next, construction of the heat transfer inhibiting means 11 is described in detail with reference to Fig. 3. As shown in Fig. 3, the heat transfer inhibiting means 11 is so constituted that the flow passage 2 is intercepted halfway with the upstream-side end portion of the downstream-side flow passage 2 larger in diameter than the downstream-side end portion of the upstream-side flow passage 2, where the two parts are concentrically overlapped with each other over a specified length and a heat insulating material 14 made of ceramics or the like is provided therebetween. Therefore, heat transferred from the helical part 5 along the flow passage 2 is inhibited by the heat insulating material 14 from being further transferred to the upstream side.

Also, the heat transfer inhibiting means 11 is so designed that temperature of A point, which is the entrance point, will be not more than 80° C while temperature of B point, which is the exit point, will be not less than 180° C. That is, a temperature range of about 80 - 180° C, which is more likely to cause crystallization of urea water or generation of unnecessary intermediates, is limited to the site where the heat transfer inhibiting means 11 is provided, while the length of this temperature range site is made as short as possible. Thus, the crystallization of urea water or the generation of unnecessary intermediates is suppressed to a minimum.

With such a constitution as described above, now its operation is described. From the inlet nozzle 3, about 20% concentration urea water is supplied at a flow rate of about 10 milliliters/min., and this urea water is conveyed within the flow passage 2 by air (flow rate: about 30 liters/min.) coming through the air supply line 4, thus the urea water air reaching the helical part 5. Then, the urea water, while flowing through within the helical part 5, is heated to about 200 - 500° C by the heating means 7, by which ammonia is generated. The resultant ammonia is supplied to the NOx removal system (not shown).

Therefore, according to the above constitution, urea water can be continuously heated while flowing at a flow rate, so that the efficiency of heat transfer is greatly improved. Also, because of a small content of urea water within the helical part 5, the rise time from when the urea water begins to be supplied until when a steady-state generation of ammonia is reached is shortened, and besides the heating capacity of the heating means 7 can be reduced. Also, because of the provision of the heating means 7 inside the helical part 5, the amount of heat release to outside is suppressed as much as possible, and besides the whole apparatus is compact in structure. Further, because of the provision of the heat transfer inhibiting means 11 and the elastic sealing member 13, the crystallization of urea water and the generation of unnecessary intermediates are suppressed to a minimum.

For intermittent generation of ammonia, the supply of urea water from the inlet nozzle 3 is controlled to an intermittent one in response to a request signal for ammonia generation. In this case, the air from the air supply line 4 is supplied at a specified amount continuously even while the supply of urea water keeps halted, so that the urea water does not reside within the flow passage 2. Further, with the supply of urea water halted, the heating means 7 also continues operating so that the temperature of the helical part 5 is maintained at a specified temperature. Accordingly, while the ammonia generation is halted, neither the crystallization of urea water nor the generation of unnecessary intermediates occurs in the helical part 5, so that the generation of a specified amount of ammonia can be started immediately upon resumption of ammonia generation.

In this connection, for cleaning of the interior of the flow passage 2, it is also possible to supply water as a cleaning fluid from the air supply line 4 instead of air, and to thereby clean the interior of the flow passage 2, while no ammonia is generated with the supply of urea water halted. That is, the air supply line 4 is made to serve as a cleaning fluid supply line. The supplied cleaning fluid cleans away the remaining urea water or its crystallized matters in the urea water introducing part 1 and the flow passage 2, and discharges them outside via a discharge line (not shown). Also, supply of the

cleaning fluid may be controlled so as to be effected when a blockage within the flow passage 2 is detected. Furthermore, the cleaning fluid supply line may be provided separately from the air supply line 4, and connected to the upstream side of the heat transfer inhibiting means 11 where the crystallization of urea water is more likely to occur.

For the heating of urea water by the heating means 7, it has been arranged that the helical part 5 is previously heated by the heating means 7 before supplying the urea water, so that the interior of the helical part 5 is heated up to a specified temperature in advance. However, there is a time delay until the flow passage 2 between the heat transfer inhibiting means 11 and the helical part 5 is heated up to a specified temperature. Therefore, during the time interval, the crystallization of urea water or the generation of unnecessary intermediates is more likely to occur in the flow passage 2 between the heat transfer inhibiting means 11 and the helical part 5. Thus, it is also possible to pre-heat the flow passage 2 between the heat transfer inhibiting means 11 and the helical part 5 by supplying humidified air (temperature: about 350°C) to part of the flow passage 2 immediately downstream of the heat transfer inhibiting means 11.

Next, a second embodiment as shown in Fig. 4 is described, where the same constituent members as those of the foregoing first embodiment are designated by the same reference numerals and their detailed description is omitted. In this

second embodiment, inside the cylindrical member 6, a threaded member 15 is inserted and the helical part 5 is formed. More specifically, the threaded member 15 is formed into a trapezoidal thread, where a screw thread with a trapezoidal cross section is formed at the outer circumferential surface of the threaded member 15, the top of this screw thread is in contact with the inner circumferential surface of the cylindrical member 6, and the thread groove forms the flow passage 2. Also, an insertion hole 16 for inserting the heating means 7 is provided inside the threaded member 15.

According to this second embodiment, since the helical part 5 is formed only by inserting the threaded member 15 into the cylindrical member 6, assembly work becomes simpler and the number of assembly man-hours is reduced. Also, even upon occurrence of blockage within the helical part 5 due to the crystallization of urea water, the threaded member 15 can be pulled out and removed, and the outer circumferential surface of the threaded member 15 and the inner circumferential surface of the cylindrical member 6 can be cleaned with great ease.

Further, another embodiment of the heat transfer inhibiting means 11 is described with reference to Fig. 5. The heat transfer inhibiting means 11 shown in Fig. 5 has a so-called ejector structure, where air is introduced from outside, and heat that has been transferred from the helical part 5 side is collected by the air, and a flow of the air that has collected

the heat is directed toward the helical part 5, by which heat is returned to the helical part 5. That is, part of the flow passage 2 is formed into a double-cylindrical structure comprising an outer cylindrical part 17 and an inner cylindrical part 18. A specified number of air inlet holes 19, 19, … are formed in the outer cylindrical part 17 along its periphery, a front-end opening 20 of the inner cylindrical part 18 is placed inside a tapered portion 21 in the downstream-side end portion of the outer cylindrical part 17, and an annular flow port 22 is formed therebetween. In addition, the upstream-side end portion of the outer cylindrical part 17 is closed.

Accordingly, when the air accompanied by urea water passes through the front-end opening 20, outside air is sucked up through the flow port 22 via the air inlet holes 19. Then, heat that has been transferred from the helical part 5 to the outer cylindrical part 17 is collected by inflow outside air so as to return to the helical part 5, thus inhibiting the heat from being transferred to the inner cylindrical part 18. Also, the heat transfer inhibiting means 11 is so designed, as that shown in Fig. 3, that the temperature of A point, which is the entrance, will be not more than 80° C, and that the temperature of B point, which is the exit, will be not less than 180° C. That is, a temperature range of about 80 - 180° C, which is more likely to cause crystallization of urea water or generation of unnecessary intermediates, is limited to the site where the heat transfer

inhibiting means 11 is provided, while the length of this temperature range site is made as short as possible. Thus, the crystallization of urea water or the generation of unnecessary intermediates is suppressed to a minimum.

In addition, the heat transfer inhibiting means 11 shown in Fig. 5 can be used either in the first embodiment or in the second embodiment.

According to the present invention, urea water can be continuously heated while flowing, so that the efficiency of heat transfer can be greatly improved. Besides, the size of the ammonia generating apparatus can be downsized as a whole and, in particular, with the heating means provided inside the helical part in the flow passage, the ammonia generating apparatus can be formed more compact in structure.